Can Opportunities Lost Be Regained? Reframing Genetic Engineering for Crop and Livestock Improvement

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The rapid and continuing global adoption of modern agricultural biotechnology has been encumbered by steadily increasing public anxiety. Scientists and regulators continually point to the weight of evidence showing that genetically-engineered (GE) crops pose negligible risks to human health and the environment. Interestingly, this very argument may lead to the counterintuitive result of the public viewing the technology as unsafe. Unraveling this quandary requires consideration of the relationship of risk to safety, the effects of public questions on regulatory processes, and the problem of risk stigma. And critically, we must ask if the correct messages have been framed and the appropriate messengers tasked to communicate the key importance of modern biotechnology to a safe, secure and sustainable food supply. As we look to the special opportunities afforded by new breeding technologies, especially new DNA-editing approaches, it is essential to identify and understand where opportunities for effectively addressing modern biotechnology have been lost in dealing with transgenic crops. And we must ask whether there is the ability to reframe genetic engineering using these new technologies in agriculture in a way that more effectively connects with the public.

Judgment of Food Safety

Despite nearly two decades of safe use worldwide, large segments of the public continue to express concerns regarding foods derived from modern biotechnology. As Europeans became aware of GE-derived foods late in the 1990s, their initial concern that they were "risky" rapidly declined (Gaskell *et al.*, 2006), but the judgment that they are unsafe remains (Gaskell *et al.*, 2010). During this same period, US consumers became increasingly aware of the reality of GE products in the food supply. Concerns about these products have increased to the point where, today, significant percentages of Europeans and Americans alike view GE-derived foods as unsafe (Hallman *et al.*, 2003; Bonny, 2008; Gaskell *et al.*, 2010; Langer, 2014). Consumer concerns relate less to the risks of these foods, which are broadly recognized as very low, and rather to uncertainties regarding the nature of the risks they may pose. Since risk represents the probability of an unwanted outcome as balanced against safety, which reflects willingness to accept a given level of risk (Lowrance, 1976), uncertainties in the nature of the risk lead many to deem these products as unsafe.

Consumer Anxiety

Biosafety specialists continue to answer concerns regarding transgenic crops and derived foods by pointing to the weight of evidence showing negligible risk (European Commission, 2010; Nicolia *et al.*, 2013) as well as to the elaborate regulatory processes that have been established to evaluate GE crops prior to their release to the marketplace [see, for instance, the history and description of the US coordinated framework (McHughen and Smyth, 2008)]. The complexity of current regulatory systems and the continuing questioning of regulatory processes and decisions have led to delays in decision-making (Smyth *et al.*, 2014). Complex and prolonged regulatory assessments create public uncertainty surrounding what are deemed very low probability risks. Further uncertainty is engendered by activists who challenge scientific consensus and regulatory findings based on the association of biosafety information and specialists with industry [see, for instance, Bauer-Panskus and Then (2014)]. Additionally, these technology opponents use words and images to great semiotic effect to create risk stigma (Slovic *et al.*, 2001). The uncertainty represented in regulatory complexity and delayed decision-making, in addition to the stigma of GE-derived foods generated in public debate, stimulates consumer anxiety.

Scenarios of very-low-probability risk with uncertainty create anxiety for individuals, which economists describe in terms of second order risk (Seo, 2009). Under such conditions, there is a strong tendency to reject low-probability risk with uncertainty in favor of an outcome with greater certainty. This has been shown for food choices where the consumer will pay more to avoid uncertainties surrounding what are very-low-probability risks (Kivi and Shogren, 2010) and appears to be the situation with regard to public attitudes toward foods derived from GE crops. Increasingly complex regulatory processes and delays in decision-making feed into uncertainties regarding the very-low-probability risks associated with GE-derived foods. Avoiding the anxiety due to the uncertainties surrounding risk leads to a willingness to consider a low-probability risk as unsafe. The desire to avoid uncertainties is reflected in actions such as support for labelling of GE-derived foods.

Window of Opportunity

Consumer preferences for unambiguous food choices are best addressed by information that reduces ambiguity (Kivi and Shogren, 2010) and so effective public communication to build knowledge and trust should lead to more well-reasoned judgments as to safety. As we encounter new breeding technologies, especially site-directed gene-editing techniques, there would appear to be a window of opportunity to reframe public understanding of genetic engineering in agriculture to reduce ambiguity in individual choice. Key to this will be the presence of trusted sources of information.

One upshot of modern agricultural biotechnology and the questions it has engendered is the establishment of a large cadre of biosafety specialists in government, industry and, to a smaller degree, in the public sphere. As scientists, regulators and risk assessors, these individuals evaluate the risks of GE crops and derived foods. Meeting at venues throughout the world to discuss the sad state of public opinion and the regulatory process, these experts continue developing more nuanced approaches for risk assessments and are training an ever-expanding universe of biosafety specialists. It is largely this body of expertise that we call upon to communicate the risks and safety of products of modern biotechnology, but the very presence of these specialists and the growth of their discipline suggests to the public that uncertain consequences of genetic engineering are worthy of concern.

What are lost here are spokespersons who can counter this risk-focused view of modern agricultural biotechnology and who can communicate, not only in words but through their actions, the benefits to food safety, security and sustainability. Much has been said about the decline in public-sector plant breeders and the shift in agriculture to more fundamental research (*e.g.*, Thirtle *et al.*, 2001). Much of this occurred late in the 20th century and has been linked to the rise in genetic engineering (Murphy, 2007). What bears repeating is the key importance of public-sector agricultural scientists as recognized experts connecting genetic engineering to food production and the public good (Thro, 2003). As public-sector plant breeders have become fewer in number and the emphasis of agricultural scientists has shifted to more fundamental considerations, consumers have lost site of the relationship of the research and development enterprise—both public and private—to food sustenance and sustainability. With limited public voices attesting to benefits of modern agricultural biotechnology balanced against their costs, we are left with polarized views that argue points of risk and uncertainty that leave the public increasingly anxious. Offsetting this anxiety requires the cultivation of public-sector agricultural scientists who, by virtue of the work they do, can be trusted voices in communicating the practice of genetic engineering as a key benefit to our modern food-productions systems.

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